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THE PRE-RICHMOND UNCONFORMITY IN THE MISSISSIPPI VALLEY

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Ulrich and Schuchert[1] have called attention to the widespread emergence of the land in the interior of North America at the beginning of the Richmond stage of later Ordovician time, and the resubmergence of the same during the later portion of the same stage. This epoch in the geologic history of the North American continent is one which has usually been overlooked, but which, nevertheless, is of vast importance.

During mid-Ordovician time a great interior sea reached westward from Appalachia to the Rocky Mountain region. In this sea the Trenton limestone of New York, New Jersey, and Pennsylvania was being deposited, as well as the equivalents of this formation farther west, the Galena limestone of Wisconsin, Minnesota, northern Illinois, and Iowa, and the Kimmswick limestone of southern Illinois and southern Missouri. In the Big Horn Mountains of Wyoming the greater portion of the Big Horn limestone is also contemporaneous in age with the Trenton and Kimmswick limestones of the east. In the regions between these outcropping areas, now occupied by younger formations, limestones of similar age are doubtless buried beneath the younger strata.

Following mid-Ordovician or Mohawkian time, this great interior sea became much contracted, so that the beds of Utica and Lorraine age, the two lower divisions of the upper Ordovician or Cincinnatian period, are restricted, so far as known, chiefly to the region lying east of the Cincinnati arch. During Richmond time, however, the interior sea again transgressed to the west and north until it again stretched from Appalachia to the Rocky Mountain region. The evidence for this withdrawal and readvance of the interior sea in post-Trenton times is both paleontologic and stratigraphic in nature, and some portions of this evidence will be considered in the following pages.

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[1] E. O. Ulrich and Charles Schuchert, "Paleozoic Seas and Barriers in Eastern North America," *Report of the New York Paleontologist for 1901*, pp. 645, 646.

In the earlier work of the geologists of Illinois, Wisconsin, Iowa, and Missouri, no important subdivisions of the Cincinnatian, or "Hudson River" as it was usually termed, were recognized, and consequently, in the absence of any conspicuous stratigraphic unconformity, the sequence from the Trenton limestone or its equivalent to the close of the Ordovician seemed to be complete. More recent critical investigation of the Cincinnatian faunas in the Ohio Valley has demonstrated that at least three distinct faunal divisions, the Utica, Lorraine, and Richmond, are included in the period, and the only one of these which has been recognized anywhere in Illinois and Wisconsin or in the region to the west belongs to the highest or Richmond division of the Cincinnatian period.

The fauna of the Richmond in the Mississippi Valley exhibits two facies, or perhaps more properly two sub-stages, which are more or less different in character. In the Richmond fauna proper, as typified by the fauna of the beds at Richmond Indiana, the brachiopod *Rhynchotrema capax* is by far the most characteristic species, and beds bearing this same fauna occur at many localities in Illinois, Wisconsin, and Missouri.

In northwestern Illinois and eastern Iowa, however, a second faunal facies occurs in the Maquoketa shales, where an important element in the fauna consists of a large number of small pelecypod shells belonging to the genera *Cleidophorus* and *Ctenodonta*, *Cleidophorus neglectus* being perhaps the most conspicuous species. The fauna of the Maquoketa beds, however, is not uniform throughout, and faunules are frequently present in Iowa and elsewhere containing examples of *Rhynchotrema capax* and other members of the typical Richmond fauna. At points farther south in the Mississippi Valley, in Jefferson County, Missouri, and Monroe County, Illinois, the typical Maquoketa fauna with an abundance of *Cleidophorus neglectus* occurs in certain shales immediately superjacent to a limestone bearing the typical *Rhynchotrema capax* fauna of the Richmond, so that the Maquoketa is shown to be at least as young or even younger than the Richmond proper.

The faunal break in passing from the subjacent Trenton horizon to the superjacent Richmond or Maquoketa is sharp, there being little or nothing in common between the lower and the upper faunas, and the unconformity suggested by this faunal change is confirmed by an actual physical unconformity between the strata over a large area.

The locality where the physical unconformity is most conspicuously shown is in southern Calhoun County, Illinois, on Madison Creek south of Batchtown. At this point the typical Richmond with its *Rhynchotrema capax* fauna does not occur, the section being as follows:

1. *Maquoketa shale*, 75 feet in thickness. In the upper part this formation is a very fine-grained clay shale of a light greenish color, weathering to an olive green, some layers containing an abundance of graptolites. In its lower beds the formation becomes yellower in color and more gritty in texture, and in the lowest six or eight feet are several harder and still more gritty beds from one to three inches in thickness which stand out upon weathered banks by reason of their greater resistance. In these harder layers fossils rarely occur, the only two genera observed being *Leptobolus* and *Cleidophorus*. At the very base of the formation is a granular bed one inch or less in thickness which is filled with examples of *Cleidophorus neglectus*, besides several species of *Ctenodonta*, a small *Orthoceras*, several gastropod shells, and an occasional fragment of a trilobite.

2. *Red residuary clay*, four to ten inches in thickness, in which are imbedded numerous angular, fossiliferous cherts.

3. *Kimmswick limestone*, ±50 feet in thickness. This is a light-colored, highly fossiliferous, crystalline limestone of Trenton age. Its superior surface is very uneven beneath the residuary red clay that rests upon it.

The unconformity in this section is represented by the red residuary clay lying between the Kimmswick limestone and the Maquoketa formation. This material can only have been formed as the product of the subaerial decay of rocks, doubtless of limestones which originally were present above the present uppermost layer of the Kimmswick limestone. The deposit is similar in every respect to the red residuary clays which are so uniformly present in southern Missouri and elsewhere beyond the glacial border, sometimes many feet in thickness, and containing the resistant cherts which were originally included in the limestone formations now destroyed by weathering. The presence of this residuary clay in the section is conclusive evidence of the existence of an area of dry land in the Mississippi Valley region, probably of long duration, between the period of deposition of the subjacent Kimmswick limestone and the superjacent Maquoketa shale. The presence of this bed at this point is perhaps only local, but the remarkable fact is that any of this residuary clay should have been preserved actually *in situ*. With the readvance of the sea it would seem that the wave action would have washed the underlying hard rocks clean of their covering, and indeed the few inches here present may be only the remnant of a former

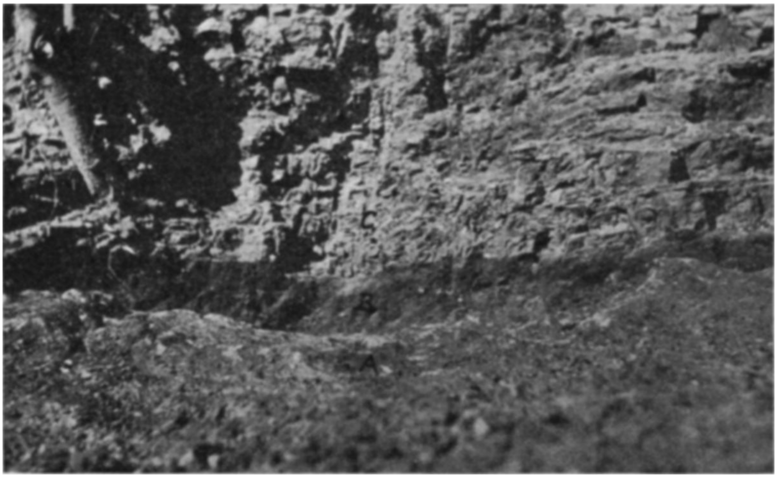

FIG 1 —Unconformity between Kimmswick limestone and Maquoketa shale near Batchtown, Calhoun Co., Ill. A, Kimmswick limestone; B, Red residuary clay; C, Maquoketa shale.

much thicker bed. That these few inches of clay, however, are in the main actually undisturbed is quite apparent, only the uppermost layer, a fraction of an inch in thickness, showing evidence of having been reworked by the waves, by reason of the mingling of Maquoketa fossils.

In passing southward this stratigraphic interval is next encountered in St. Louis and Jefferson Counties, Missouri, and in Monroe County, Illinois. In none of this more southern area has such a striking instance of physical unconformity been observed as that near Batchtown, but the unconformity is none the less distinctly shown. The section in this region is slightly different from the Calhoun County section, by reason of the presence of the true Richmond with its *Rhynchotrema capax* fauna, and may be somewhat generalized as follows:

1. *Burlington limestone* and *Kinderhook beds*, whose differentiation is not of importance in this place, resting unconformably upon the Maquoketa shale.

2. *Maquoketa shale*, 4 to 30 feet in thickness, often with abundant graptolites in the higher beds, and with the typical *Cleidophorus neglectus* fauna at the base. This formation exhibits much variation in different vertical sections in the region, but it always contains the typical Maquoketa fauna.

3. *Richmond limestone*, ±2 feet in thickness. This is a hard, more or less impure limestone, somewhat darker colored than that below. It is abundantly fossiliferous, the most conspicuous species being *Rhynchotrema capax*. This bed is remarkably uniform in character, both lithologically and faunally, throughout this region of outcrop.

4. *Kimmswick limestone*, ±50 feet in thickness. The outcrop of this limestone along the Mississippi River in Jefferson County constitutes the typical expression of the formation. It is remarkably uniform in all of its characters, with the same formation in Calhoun County.

In any single vertical section in this region the physical unconformity between the Kimmswick limestone and the Richmond bed is not conspicuously exhibited, although the faunal change is sudden and complete. In following the contact from the section at the railroad cut one mile south of Kimmswick, however, to the quarry at Glen Park, and then in the sections of the river bluffs to an abandoned quarry one-half mile farther down stream, a total distance of from two and one half to three miles, it is clearly seen that the Richmond rests upon higher and higher strata of the Kimmswick limestone. At the northern end of this section the uppermost bed of the Kimmswick, immediately beneath the Richmond, is characterized by a fauna in which bryozoans are the most conspicuous element. At Glen Park the upper bed of the Kimmswick is a higher stratum than that farther north, and the fauna contains more trilobites and pelecypods. Farther south a still higher bed of the Kimmswick limestone, characterized by many specimens of a large *Receptaculites*, is immediately subjacent to the Richmond. These stratigraphic conditions clearly indicate that in post-Kimmswick time the region was elevated above sea level, and the beds obliquely truncated before the deposition of the Richmond. The time hiatus represented by the unconformity in this region, as in Calhoun County, is doubtless the period during which the Utica and Lorraine formations were being deposited east of the Cincinnati arch.

In Monroe County, Illinois, conditions identical with those in Jefferson County, Missouri, are shown in the quarry of the St. L. I. M. & S. R. R. at Valmeyer. Still farther south, at Cape Girardeau, Missouri, the same section is repeated in the same manner, although the details have not been so carefully studied as in the more northern localities.

In the northern portion of the Mississippi Valley region, in eastern Iowa, northwestern Illinois, and Wisconsin, no stratigraphic break between the Galena limestone below, which is contemporaneous with the Kimmswick limestone, and the superjacent Maquoketa shales has been certainly established, but the faunal break is essentially identical with that in Calhoun County where the physical break is clearly shown, and one is forced to the conclusion that the physical unconformity is really present, although obscured.

Westward from the Mississippi River, across the great plains, the older rocks are completely buried beneath younger formations. In the Big Horn Mountains in Wyoming, however, as has recently been shown by Darton,[1] conditions are present which are comparable to those in the Mississippi Valley. In this western region the great mass of the Big Horn limestone corresponds essentially in age to the Kimmswick limestone, but at the summit of the formation, in discontinuous, pocket-like areas, as if deposited unconformably upon the eroded or weathered surface of the subjacent beds, are strata bearing a rich and typical Richmond fauna with *Rhynchotrema capax*.

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[1] "Geology of the Big-Horn Mountains," *U. S. Geological Survey*, P. R. No. 51, pp. 26–29; also *Bull. Geol. Soc. Am.*, Vol. XVII, p. 547.

With this unconformity clearly established in the Mississippi Valley and in the Big Horn Mountains, and with the faunal conditions so nearly alike in the two regions, we seem to be justified in considering the same unconformity as being present in all the intervening area. If this conclusion is well founded, there must have been in post-Trenton time a great expanse of dry land in the interior of the North American continent, reaching from the Cincinnati arch probably to the Rocky Mountain region, which in Richmond time was resubmerged.

Such a widespread emergence and resubmergence of the interior of the continent should constitute an important and clearly marked epoch in geologic history, perhaps of sufficient importance to rank as a major division in this history. As we now understand the facts, there seems to be no such conspicuous break between the recognized summit of the Ordovician and the base of the Silurian, as this preceding the Richmond. A thorough and systematic investigation of the entire Richmond and Maquoketa fauna, together with a careful comparison with the earliest Silurian faunas is highly desirable. It is especially desirable that the earliest faunas of the Medina sandstone of the east be better known, in order to determine whether there exists any relationship between them and the Richmond faunas of the Mississippi Valley. In a certain way the Richmond is perhaps analogous with the Helderbergian which was formerly considered as the youngest Silurian, but is now almost universally considered as the oldest Devonian. It is certainly within the limits of possibility that, with a more complete knowledge of the facts, the Richmond may be transferred in a similar way, and be considered as the oldest Silurian, rather than as the youngest Ordovician.